U.S. Department of Agriculture Agricultural Research Service

Jan-Feb 1983

Agricultural Research

ARS Program Plan—Goals and Objectives

The most exhaustive planning ever undertaken by the Agricultural Research Service charts new directions for the future and shifts funding toward high-priority research in order to ensure U. S. agriculture's mission —the perpetual production of food and fiber.

More than a year in the making, the Program Plan is being made public this month and will be implemented immediately.

The design of the ARS Program Strategy provides for building most effectively on our present scientific knowledge base. We will identify the most promising research opportunities, both basic and applied, by considering the supporting knowledge base, and the probability of success.

The following paragraphs outlining ARS's goal and the six objectives of the plan are excerpted from the actual Program Plan.

Goal:

Through fundamental and applied research, ARS seeks to provide the means for solving the technical food and agricultural problems of broad scope and high national priority as required to ensure, perpetually, an adequate supply of high-quality food and fiber for the American people and for export.

Objectives:

Develop the means for:

1. Managing and conserving the Nation's soil and water resources for a stable and productive agriculture;
2. Maintaining and increasing the productivity and quality of crop plants;
3. Increasing the productivity of animals and the quality of animal products;
4. Achieving maximum use of agricultural products for domestic markets and export;
5. Promoting optimum human health and well-being through improved nutrition and family resource management; and
6. Integrating scientific knowledge of agricultural production, processing, and marketing into systems that optimize resource management and facilitate transfer of technology to users.

All six of the objectives are essential, and achieving them wholly or in part will help meet the state goal. Conservation and restoration can ensure that the resource base remains adequate for future generations. Increasing the production efficiency of our crop plants and livestock should help ensure farmers' margins of profit and provide food and fiber to consumers at reasonable costs.

Poducing food and fiber crops, however, is not enough; raw materials must be processed and delivered in an efficient and timely manner for ultimate consumption. Through all stages of production, marketing, and consumption, products must be protected against losses from diseases and from insects and other pests. Just as important are the safety, wholesomeness, and quality of products, especially of the basic foodstuffs.

Finally, it is necessary that research data be integrated into models for systems analysis. Through this, we should help to increase efficiency in production and marketing, improve assessments of environmental consequences, and foster technology transfer. In this way we can help understand the vast scope of the Nation's agricultural system and improve and protect it for the future. □

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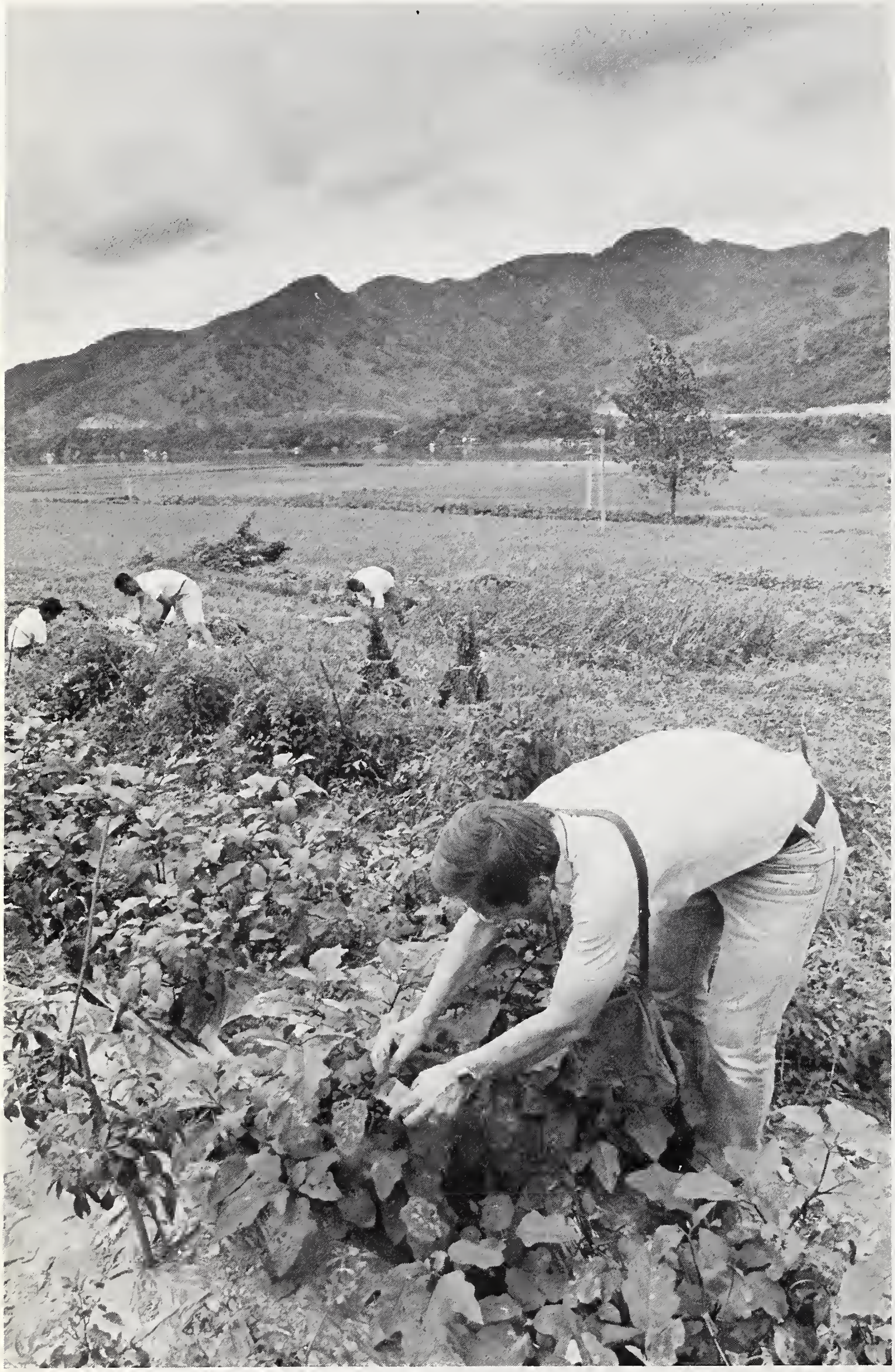
Cover: The blue orchard bee *(Osmia lignaria)* is just one of several species of non-honey-making wild bees that pollinate certain crops better than honey bees. Ongoing research aims to find more of these specialized bees to benefit orchard and crop production. Article begins on p. 8. (0682X599-11)

The Asian Parasite Laboratory



Entomologist Robert W. Carlson examines eggplants for possible natural enemies of *Henosepilachna vigintioctomaculata*, an Asian pest closely related to the Mexican bean beetle, which attacks U. S. soybeans. Carlson hopes that predators and parasites of this Oriental relative will adapt to the American pest. (1082X1244-7)

With the opening of the Asian Parasite Laboratory in Seoul, Korea, ARS is intensifying its search of the Asian mainland for natural enemies of insect pests in this country. At the new facility, entomologist Robert W. Carlson identifies, studies, and rears large numbers of the most promising insect parasites and predators for shipping to stateside ARS laboratories for further evaluation.

Many of the insects that annually devour millions of dollars in U.S. crops are unwanted imports from foreign shores that have left their natural enemies behind. The Seoul lab, opened in June 1982, is one of four overseas ARS facilities whose mission is the discovery, study, and exploration of natural enemies to control "naturalized" exotic pests in the United States. "Such biological control of insects is an increasingly important way to protect our environment while meeting American expectations of food quality, quantity, and variety," Carlson says.

Insects that feed on food crops are not Carlson's only targets. Red pine scale *Matsucoccus resinosae)* and hemlock scale *(Fiorinia externa)* are also Asian Parasite Lab priorities, as is the Japanese beetle *(Popillia japonica)*.

Equally high on the exotic pest hitlist are the pear *(Psylla pyricola)*, a plant louse threatening Northwestern fruit growers, and the gypsy moth *(Lymantria dispar)*.

In 1981, the gypsy moth stripped a recordbreaking 12 million acres of hardwood forest. "Gypsy moths are found everywhere in Korea, but they are not a pest there. By collecting the moths from the wild, we hope to learn why," Carlson says. Last spring, he and assistant Kim Chung-ja and Han Ho-Yeon scoured forests of chestnut and oak north of Seoul. They collected the eggs, larvae (caterpillars), and pupae (cocoons) of the large, mottled-brown moth. What they really bagged, however, were the gypsy moth's many natural enemies. Tachinid flies, chalcidoid, ichneumonid, and braconid parasitic wasps were among the apparent natural enemies that Carlson, Kim, and Han collected. They also collected a previously unidentified species of pyralid moth whose larval form is a suspected predator of gypsy moth eggs.

Once Carlson completes his initial studies and raises large numbers of the most promising species, he sends them by air to the Beneficial Insects Research Laboratory in Newark, Del., and the Stoneville Research Quarantine Facility in Stoneville, Miss. Here the insects are quickly uncrated and placed in quarantine to prevent their escape until their own parasites are eliminated. At Newark and Stoneville, the natural enemies are further evaluated. Some are sent to other state and Federal laboratories throughout the country.

Carlson's work does not end with the capture and export of these biological control agents. In some ways, it is just beginning. The host/parasite/predator relationship is very complex. It is influenced by many physiological, behavioral, and ecological variables. Insects within the same species can vary genetically, depending on where they live. For example, female gypsy moths in Asia can fly; their American and European counterparts cannot. Natural enemies also vary. For reasons that scientists are still uncovering, a natural enemy that controls an insect in one place may fail in another.

"An understanding of these complexities is critical to our success," says Carlson. "What plays in Seoul may not play in Seattle."

Therefore, in addition to exporting natural enemies to the United States, Carlson and his counterparts at ARS facilities in Buenos Aires, Rome, and

Far left, top: Carlson stands before the Asian Parasite Laboratory in Seoul, Korea. (1082X1241-22)

Far left, center: Research assistant Han Ho-Yeon holds one undamaged eggplant leaf (right) and one damaged by overnight feeding of *Henosepilachna vigintioctomaculata* under laboratory conditions. Damage in the field is more subtle. (1082X1237-23a)

Far left, bottom: *Henosepilachna vigintiocto-maculata* larvae—a relative of the Mexican bean beetle—on an eggplant leaf. (1082X1239-17)

Above: Avoiding the beetle larvae's spines, a tiny parasitic wasp *(Pediobius foveolatus)* prepares to lay its eggs inside its host. (1082X1242-9a)

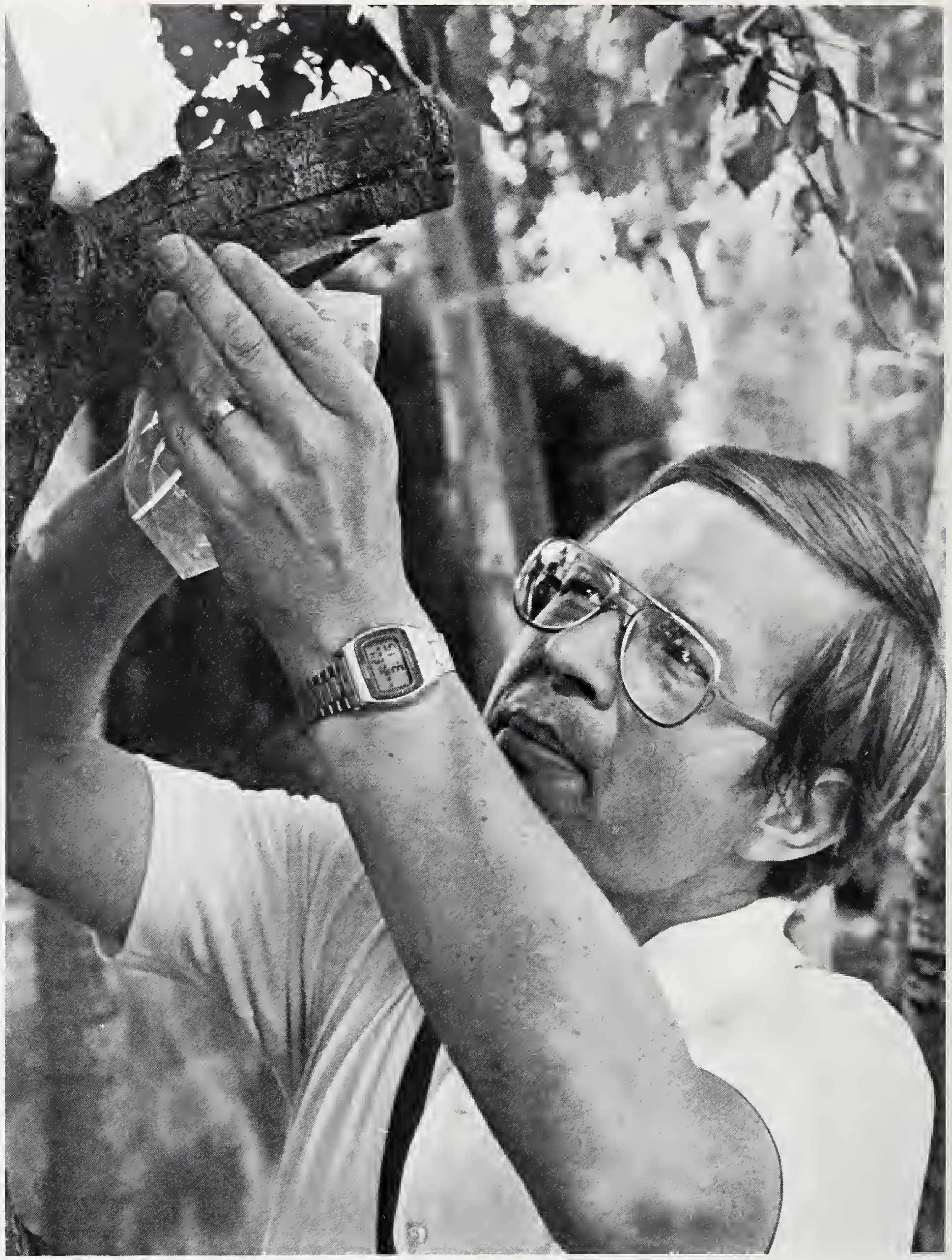
near Paris, study insect behavior and ecology as well. Host ranges, biologies, distribution, rearing, and evaluation techniques are all equally important to the successful introduction of a biocontrol agent.

By exploiting the relationship between pest and predator, a good natural enemy may become a great one, according to Carlson. For example, an Asian wasp *(Pediobius foveolatus)* is being used to control the Mexican bean beetle *(Epilachna varivestis),* which annually costs U.S. soybean growers millions of dollars. The wasp lays its eggs in the beetle's destructive larvae. When the eggs hatch, the wasps' larvae eat the beetle.

The problem is that the wasps, which were brought from subtropical parts of India, cannot survive our winter. Each spring, large numbers of wasps must be reared and released again—an expensive, time-consuming process. "If we can discover how this wasp overwinters in Korea and colder regions of Asia, it might become a year-round resident of the United States," Carlson says. "A one-time release of the wasp in conjunction with other control methods—such as pesticides, sex attractants, and traps—could be enought to send the bean beetle packing."

The Asian Parasite Laboratory is cosponsored by the South Korean Government. In return for laboratory and greenhouse space, ARS provides the Korean Office of Forestry with technical assistance including access to the computer-based literature services of the U.S. National Agricultural Library in Beltsville, Md., and the identification of insect and mite specimens by the Systematic Entomology Laboratory of Beltsville's Insect Identification and Beneficial Insect Introduction Institute. The agreement may become a model for U.S. cooperation in biological control research with other nations.

Robert W. Carlson is located at the Asian Parasite Laboratory, c/o American Embassy (Seoul), APO San Francisco 96301.—(By Andrew Walker, Beltsville, Md.) ■



Carlson collects a gypsy moth caterpillar *(Lymantria dispar)* from a cottonwood tree to inspect it for parasites and predators that may contribute to natural control of the pest in Korea. (1082X1235-24)

Developing Alfalfa as an Annual Crop

Scientists in ARS are redesigning alfalfa in basic research for use as an annual to enhance its value in crop rotations, potentially one of this nation's best tools for maintaining soil productivity.

The new alfalfa, expected to be available to growers sometime in the late 1980's, also could be grown where land is now fallowed, plowed and left idle for a year. Such a vegetative cover would help prevent water and wind erosion of exposed land.

A major goal of the research team, headquartered at St. Paul, Minn., is to breed an alfalfa for use as an annual crop that, besides providing feed for livestock, will leave 150 pounds of nitrogen an acre when plowed down for the following year's crop of corn or small grain. In limited field tests to date, the team has increased grain yields by 11 percent as a result of added nitrogen provided to a corn crop that followed an experimental line of alfalfa grown as an annual.

Alfalfa is one of the most efficient legumes in capturing nitrogen from the atmosphere through rhizobium bacteria that live symbiotically with the plant in nodules on the roots.

The research team is using as one of its primary tools a composite breeding line of alfalfa dubbed BIC-7 (Beltsville International Composite). It was developed in the 1950's at USDA's Agricultural Research Center, Beltsville, Md., by ARS plant geneticist Donald K. Barnes. Barnes is a member of the present-day St. Paul team, and he and other ARS scientists have since improved the original BIC-7 to enhance its insect and disease resistance.

BIC-7 contains diverse genetic characteristics from alfalfa grown in all major producing areas and is used by plant breeders worldwide. Of particular importance in the St. Paul studies are selections that can grow much later in the fall. Barnes says they continue producing nitrogen until the ground freezes, long after most other alfalfas have gone dormant.

Besides Barnes, the other team members are ARS plant physiologists Gary H. Heichel and Carroll P. Vance, and University of Minnesota forage production scientist Craig C. Sheaffer. Sheaffer leads testing of the experimental alfalfas in different cropping systems and under varying tillage practices.

One selection, Mn BIC-7, was grown in rotation with corn. Corn yields were then compared with those from corn grown on land planted to unselected alfalfa and land that had been fallowed. This yield comparison was used to measure how much nitrogen was available for increased corn production following the experimental alfalfa from which all vegetative growth was plowed under.

The added nitrogen from Mn BIC-7 converted to 11 percent more grain and 7 percent more fodder than from corn grown on land planted previously to unselected BIC-7 populations, Sheaffer says; the net returns from corn grown following Mn BIC-7 were 37 percent greater than those from corn grown on land fallowed the previous year.

Much interest has been expressed, team members say, by agricultural leaders and growers in areas where wheat and other small grains are grown following fallow, including the northern Great Plains and northwestern United States, as well as Australia.

The team now has several experimental lines of alfalfa designed for use as annuals and enough seed for testing. Beginning in 1982, tests were established at four locations representing conditions prevalent in the Middle West. The lines have been bred and selected, Barnes says, for large root mass, increased storage of nitrogen in the roots without sacrificing top growth, late fall growth, and resistance to diseases and insects.

"We're after a delicate balance required in an alfalfa grown as an annual in crop rotations," Heichel says. "It must be suitable to growers as a forage for hay or silage during the cropping season. It must also have rapid regrowth after cropping, and enough nitrogen in the roots and crowns to provide a net gain of nitrogen to the soil for use by the next crop."

The best balance so far, Barnes states, was realized when Mn BIC-7 was grown to one-tenth bloom stage, harvested for hay, and allowed to grow until plowed under. "That management system is fine for providing a net gain of available nitrogen in the soil, but it still may not be satisfactory to growers from a cost-benefit standpoint," Sheaffer emphasizes.

"Rainfall permitting, it may be more practical in Minnesota to take two cuttings, one in July and one early in September, and then plow under regrowth that occurs after the second cutting to about middle October."

"Selection for more fall growth provides a distinct advantage for alfalfa for use as an annual," he says.

Donald K. Barnes is located in the Agronomy Bldg., Rm. 404, University of Minnesota, St. Paul, Minn. 55108.—(By Robert E. Enlow, Peoria, Ill.) ■

Wild Bees as Pollinators—An Update

Birds do it. Butterflies do it. Beetles, moths, flies, and even bats do it. But on the whole, nothing does it better than bees—and wild bees often do it best of all.

The "it" is pollination, the plant reproduction process on which an estimated one-third of the human diet is dependent. And the "wild bees" are the non-apis bees—those species that do not make honey.

Bees cannot seem to shake their image as honeymakers even though few bother to make the sweet stuff. In fact, only one species of 3,500 in the United States makes honey, and only four of 20,000 known bee species worldwide do.

Despite their abundance, relatively little has been done to tap the potential of wild bees as manageable crop pollinators. So far, only two have been "domesticated." This is unfortunate because many wild bees are better pollinators than honey bees.

The all-female honey bee work force visits plants primarily to gather nectar. With the exception of a few pollen-gathering specialists in each colony, pollen collection is inadvertent, and the specialists limit themselves to plants with plenty of easy-to-collect pollen.

Among wild bee species, both male and female bees visit plants, and females visit specifically to gather pollen as a food source for themselves and their future offspring. These bees are generally able to operate under much broader and more harsh environmental conditions than honey bees.

What has hampered the utilization of wild bees by the agricultural industry is the idea that the colonizing honey bee is easier to transport and manage for planned pollination. This is an idea being disproven by ARS researchers in Logan, Utah, and Beltsville, Md.

At Logan, entomologists Frank D. Parker, Philip F. Torchio, and Vincent J. Tepedino are searching for the best possible pollinators for any given insect-pollinated crop. Though their search is global in scope, the researchers have found many previously untapped species at home to study.

"We currently estimate that only 8 percent of our native bee species are known biologically," says Parker, who leads the research at Logan. "This means we've yet to discover what most of our native bees are doing and what perhaps vital roles they have in the continuance of our flowering plant community."

Entomologist Philip Torchio inspects apple blooms visited by bees to determine the amount of pollination occurring. (0682X591-30)

"Studying the biology of a new bee species and evaluating its potential as a manageable crop pollinator is a long, frequently trying process. First, a generation of the species must be raised in the controlled environment of a greenhouse to confirm its basic reported biology. Then a field study must be run with the bees confined to a large cage in order to insure the purity of their pollination performance (no help from birds, butterflies, or bats). Follow-up field studies without cages—to evaluate the bees' performance in a natural setting—must also be run.

However, the painstaking procedure holds the promise of a great payoff in orchard productivity as evidenced by Torchio's work with a native orchard pollinator, *Osmia lignaria,* the blue orchard bee.

Economics and an expanding U.S.

Thousands of *Osmia lignaria* cocoons have been extracted from nest traps and encapsulated for release. Biotechnician Glen Trostle checks the capsules to make sure that bees have begun to emerge before they are released into apple orchards. (0682X595-26)

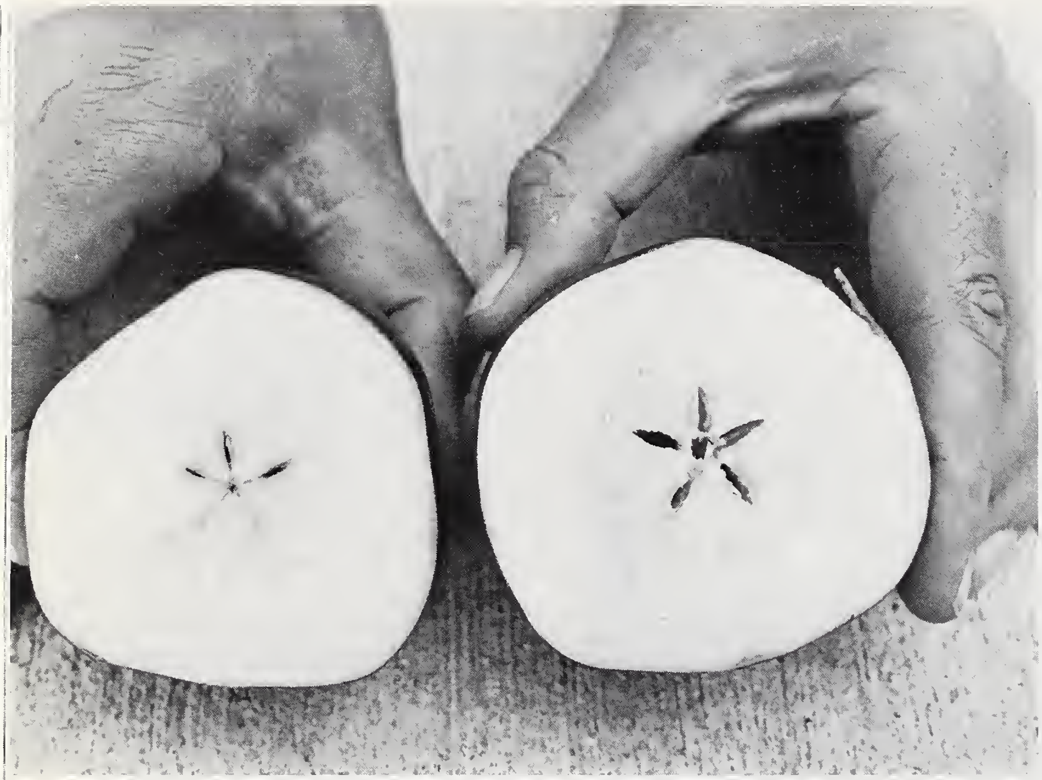
Torchio checks paper straws in which *Osmia lignaria* will nest—a trait that facilitates gathering and moving the proper number of bees from orchard to orchard to coincide with bloom periods. (0682X591-11)

orchard industry raise the need for additional orchard pollinators to supplement the honey bee. In studying bees that visit orchard blooms, Torchio found that the blue orchard bee surpasses the honey bee as an orchard pollinator and is biologically better suited for the job.

Management poses no problem, either. Gregarious nesters, readily accepting provided nesting materials, blue orchard bees can be manipulated to emerge from their nesting cells at the bloom period of any given orchard crop. With both sexes visiting blooms, maximum pollination is achieved during the short flowering periods of most orchard crops.

Torchio's most recent studies have determined that, in general, fewer than half as many blue orchard bees as honey bees are needed to pollinate most orchards. He has also begun determining the best ratio of males to females for different types of orchards. This ratio is important because when too many bees are in an orchard, females competing for pollen and nectar to provision newborn bee cells become stressed and unable to reproduce. Pollination remains good, but the bee population declines.

Based on lengthy observations, Torchio has concluded that for apple or-



The smaller, misshapen apple at left resulted from incomplete seed development caused by inadequate pollination. The plump apple typifies a fully pollinated fruit with a full complement of seeds. (0682X596-21)

chards, "250 female blue orchard bees per acre, at a sex ratio of one to one, provide good pollination for growers and increase populations for bee keepers."

Torchio is now studying almond orchards which have much different pollination requirements than apples. He suspects the ideal number of female blue orchard bees for almond orchards will be fewer than 500 per acre with up to 2 males for each female, but more observations are needed.

One of this country's most rapidly expanding crops, sunflower, is also one of the few cultivated crops native to North America. Several species of native North American wild bees have evolved with the plant as its pollinators, and Frank D. Parker has been trying to determine which of them are manageable. He's found what he terms an excellent candidate in *Eumegachile pugnata,* the sunflower leafcutter bee.

"This big bee visits all sunflower varieties, stays in the area where it is released, and nests in the densest part of a field, where there is less tendency to drift away than in the sparsely planted outer edges," says Parker.

In pollination trials, the average visit of a sunflower leafcutter bee to a plant head—which contains 1,000 to 2,000 individual flowers joined to a common base—resulted in the production of 97 new seeds. Each visit from a honey bee resulted in the production of only 15 new seeds.

Right now, the ultimate value of native wild bees to crops is anyone's guess, but most bee researchers agree that native wild bees are already contributing millions of dollars to the U.S. agricultural economy. With the proper management, they could probably contribute much, much more.

Furthermore, since the vast majority of cultivated crops in this country were introduced from abroad, the potential benefits of importing bees that evolved with a given crop at its place of origin, for use as pollination "specialists," might well even be greater.

To date, there have been only three intentional introductions of pollinators from other countries into the United States—the honey bee, a fig wasp, and most recently (1978), the hornfaced bee from Japan.

Entomologist Suzanne Batra at Beltsville, says that in comparison trials between the hornfaced bee (*Osmia cornifrons*) and the honey bee, the Japanese import pollinated 25 apple flowers for every one flower pollinated by the honey bee. Increased pollination increases fruit yields.

"The hornfaced bee is a perfect pollinator for use on small farms and home gardens," says Batra, citing the bee's mild sting and short adult lifespan as making it easy to manage.

Hornfaced bee colonies from Japan have now been established in Maryland, New Jersey, New York, North Carolina, and the District of Columbia. In addition to being good pollinators of apples, hornfaced bees are also good for peach, cherry, and plum trees.

Ongoing research may find more wild bee species—native and imported—that benefit efficient orchard and other crop production.

Frank D. Parker, Philip F. Torchio, and Vincent J. Tepedino are located at Utah State University, UMC 53, Natural Resources-Biology Bldg., Logan, Utah 84322. Suzanne Batra is located at the Beneficial Insect Introduction Laboratory, Bldg. 417, Beltsville Agricultural Research Center-East, Beltsville, Md. 20705.—(By Lynn Yarris, Oakland, Calif.; with additional material from Ellen Mika, Beltsville, Md.) ■

Basic Research for Better Soybean Oil

Agricultural researchers are using some sophisticated techniques to usher in the day when margarines, salad dressings and cooking oils containing nonhydrogenated soybean oil have nutritional quality and shelf lives that are as good as or better than today's hydrogenated products.

On their way to achieving this goal, plant geneticists, biochemists and plant pathologists, who are borrowing some applications of medical science, may learn some of the basic secrets of germination, growth and development in soybeans. At West Lafayette, Ind., a team of ARS and Purdue University scientists and postdoctoral students from Japan already has identified some soybeans that make the effort look promising.

"We're attacking a flavor stability problem in soybean oil from two angles," says ARS geneticist Niels C. Nielsen. "If we succeed with one or both of these approaches, stability of the oil may be improved."

One of the approaches is to develop soybeans that are low in linolenic acid, a substance in soybean oil that develops an undesirable flavor when the oil is exposed to oxygen in the air. It may not be possible to breed soybeans devoid of this unsaturated fatty acid. Even if it were, Nielsen says, it would be undesirable because some linolenic acid is essential in human and animal nutrition.

However, various forms or isozymes of the enzyme, lipoxygenase, are thought to play a role in generating these undesirable flavors in soybean products. That means the other approach—breeding soybeans with little or no enzyme activity that breaks down linolenic acid—may be the better alternative.

"We developed a screening routine to help us identify soybeans that lack isozymes of lipoxygenase," says Nielsen. "We plan to automate the routine so we can screen large numbers of seeds a day for quantitative characteristics such as enzyme content."

The screening for soybeans with little or no lipoxygenase content is done by a serological test called ELISA—enzyme-linked immunosorbent assay. ELISA presently is used in medicine to measure levels of enzymes, viruses, and other substances for medical purposes. The potential applications in agricultural research may only be limited by one's imagination, says Nielsen. ELISA has already proven useful for detecting pathogens in animals, diagnosing virus diseases of plants and studying the nature of diseases.

Plant breeders can take advantage of the sensitivity of ELISA. Postdoctoral student Seizo Yabuuchi, working in Nielsen's laboratory, and Purdue University plant pathologist Richard M. Lister and biochemist Bernard Axelrod have found that ELISA can measure as little as 5 to 10 nanograms of lipoxygenase protein. That means it is sensitive enough for half-seed analysis.

"We can cut a seed in half in such a way that the growing part of the seed is intact," says Nielsen. "We analyze one part and use the other half to grow a plant and produce more seed. If a plant is self-pollinated, for example, genetic information may segregate out so it is different in each seed. By analyzing seed halves, we can save the seed that has the measured characteristics in which we are interested."

Using ELISA, the scientists at West Lafayette have identified soybean lines that lack one of the isozymes, lipoxygenase 3 (L3). These lines were among those brought from Japan by postdoctoral student Keisuke Kitamura, and they are adapted to northern growing regions.

Plant geneticist Theodore Hymowitz of the University of Illinois, Urbana, has identified soybeans that lack another isozyme, lipoxygenase 1 (L1). They were found in the U.S. Southern Soybean Germplasm Collection. Postdoctoral student Corrine Davies, from the University of Wisconsin-Madison is trying to introduce the genes that confer lack of L1 and L3 into agronomically acceptable soybeans. She is also conducting studies on the linkage of these genes and other genetic markers—to learn how frequently various characteristics can be expected to exist together in the same plant.

The West Layfayette research team is creating mutations in soybeans with the hope of finding some that might prove useful for developing lines devoid of or low in L1, L2, and L3. The research team is also trying to produce mutants that vary in linolenic acid. ARS plant geneticist James R. Wilcox is evaluating these mutants and says several of them look promising.

Research on soybeans that are low in linolenic acid is oriented both to immediate application and to increasing basic knowledge. For example, scientists have yet to learn how some of the linoleic acid in soybeans is converted into linolenic acid. This process is of particular interest because linolenic acid is a major fatty acid found in chloroplasts, where photosynthesis occurs.

The research on lipoxygenase also has a basic and applied orientation. Whether soybeans without lipoxygenase can be developed, of course, remains to be seen. Some researchers have suggested that lipoxygenase may play an important role in germinating seedlings. Others are asking: Could they have a role in protecting plants from diseases? Could they have a role in biosynthesis of ethylene, which is involved in root development? The basic research being conducted by Nielsen and his colleagues may help provide answers.

Niels C. Nielsen is located at the Lilly Hall of Life Sciences Bldg., Rm. 2-302, Purdue University, W. Lafayette, Ind. 47907.—(By Ben Hardin, Peoria, Ill.) ■

Living Organisms to Control Curly Indigo

A field evaluation of dried fungus spores for use in biocontrol of curly indigo in rice and soybeans is underway at the ARS Rice Production and Weed Control Research Laboratory near Stuttgart, Ark.

"Curly indigo or northern jointvetch (*Aeschynomene virginica* (L.) B.S.P.), a black-seeded weed, is a serious pest in Arkansas rice fields that competes with rice for nutrients and light, interferes with harvest, and reduces grade and quality of rough and milled rice," says research agronomist Roy J. Smith, Jr. "Its seeds are also difficult to remove from harvested grain and are unattractive in white milled rice."

Smith worked in collaboration with George E. Templeton and David O. TeBeest, plant pathologists with the University of Arkansas, and agronomy graduate assistant Richard A. Klerk.

In Arkansas, 11 percent of the 1980 rice crop was discounted after harvest, due to the presence of curly indigo and hemp sesbania seeds, a quality loss valued at $7.6 million.

Smith reports that "lack of control of curly indigo in soybeans, grown in crop rotation with rice, results in reseeding which increases problems in subsequent rice crops and further dissemination of the weed to uninfested areas."

To achieve biological control of curly indigo, a fungus organism, *Colletotrichum gloeosporioides* f. sp. *aeschynomene* (C.g.a.), was isolated and identified. Since 1970, fresh preparations of living spores have been tested in laboratory, greenhouse, and field plot experiments and in field tests with cooperating farmers. Protocols for testing were developed with the cooperation and approval of the U.S. Environmental Protection Agency (EPA) which issued Experimental Use Permits for large-scale field tests from 1975 through 1981.

Extensive host-range tests were conducted to assure genetic stability and host specificity in experiments with several economic crops, other weeds, and environmentally important plants of the area. Specificity to curly indigo and genetic stability has been confirmed in all tests during the past 10 years.

Above: Research agronomist Roy J. Smith, Jr., compares a healthy curly indigo weed with one killed by the fungus *Colletotrichum gloeosporioides* f. sp. *aeschynomene* (C.g.a.). Curly indigo can reach 4 to 5 feet in height. (0882X981-12a)

Opposite, top: Fatal damage to the stem of a curly indigo plant demonstrates the effectiveness of C.g.a. as a biocontrol agent. Grasshoppers that feed on the lesions spread the sticky C.g.a. spores to other weeds. (0882X981-35a)

Opposite, bottom: A solitary curly indigo weed emerges amid rice plants. For effective weed control, this is the most desirable time to apply C.g.a. (0882X980-18)

Safety of the fungus to animals was assured by laboratory tests conducted by animal scientist J. N. Beasley with the Department of Animal Science at the University of Arkansas in Fayetteville. No infection or chronic symptoms were observed in animals treated with the fungus.

Assistance from industry was requested to mass produce the fungus for field trials with growers. The Upjohn Company's TUCO Division has assisted the university and ARS in providing spores for grower trials since 1974. In 1978, a formal agreement was developed between the University of Arkansas and Upjohn to commercialize C.g.a. and return a portion of net sales to the university for continuance of biological control research.

Dry, living spore formulations, produced by TUCO, have been successfully field tested with cooperating growers since 1976. The TUCO formulation of dry spores began to be marketed under the trade name COLLEGO in 1982 when registration by EPA was received.

C.g.a. controlled curly indigo well in rice and soybean fields in trials conducted in 1981. It controlled 95 percent or more of the weeds in 13 of 15 rice fields and 90 percent or more of the plants in 5 of 5 soybean fields. Preliminary evidence indicates that C.g.a. can be tank-mixed with acifluorfen, a chemical herbicide that controls hemp sesbania.

Because the product is a living organism, conditions for storing, handling, and use are different from those used with chemical herbicides. Experience has revealed the following about the effective use of COLLEGO:

- Spores may take 4 to 5 weeks to kill indigo plants.
- The fungus is suppressed or even killed by liquid nitrogen fertilizers and most pesticides, except acifluorfen; consequently, spray equipment must be cleaned with activated charcoal before it is used.
- The fungus is killed by excessive heat or cold, so the product should be stored at temperatures of 40°F to 80°F and away from pesticide vapors.
- Warm, moist, cloudy weather favors infection and disease development; rice should be flooded and soybean fields irrigated just prior to application for maximum effectiveness.
- Younger weeds are more susceptible than blooming and mature plants; curly indigo plants should be treated as they emerge through the rice and soybean canopy.
- COLLEGO will not kill Indian jointvetch (*Aeschynomene indica* L.).

Roy J. Smith, Jr., is located in the ARS Rice Production and Weed Control Research Unit, University of Arkansas Rice Research and Extension Center, P.O. Box 287, Stuttgart, Ark. 72160.—(By Neal Duncan, New Orleans, La.) ■

Orange Purees Need Temperature Control

Freshly made, whole-orange purees contain 55 to 75 milligrams of vitamin C per 100 milliliters of puree. Purees stored at cool temperatures show remarkable stability for long periods of time. Conversely, if these purees are stored at ambient temperatures for long periods, the vitamin C content will drop dramatically.

Oranges harvested early in the season have considerably more vitamin C than late harvested fruit. However, purees made from early harvested, vitamin-rich oranges will lose vitamin C after long storage at ambient temperatures until they contain about the same low amounts of vitamin C as purees made from late harvested, vitamin-poor oranges.

In a study of the long-term effects of storage on the vitamin C content of orange puree, ARS chemists Roger F. Albach and Amelia T. Murray learned that storage temperature is as important as time of harvest.

The scientists stored purees made from three orange varieties (Marrs, Pineapple, and Valencia) for periods of time ranging from 1 to 6 years at temperatures of 40° F (4° C) and 68° F (20° C).

Tests were made intermediately during this time to determine the stability of the purees.

After 6 years of storage at 40° F, one puree had 50 milligrams of vitamin C per 100 milliliters. The same puree, stored for the same length of time at 68° F, had only 17 milligrams of vitamin C per 100 milliliters.

Whole-fruit purees utilize about 85 to 90 percent of the fruit, including pulp and peel. Citrus peel contains about three times the concentration of vitamin C as does the juice. The peel also contains enzymes and antioxidants that affect vitamin C stability. At this time, scientists do not know exactly how much the enzymes and antioxidants affect whole-orange puree.

Roger F. Albach and Amelia T. Murray are located at USDA's Agricultural Products Technology Research Unit of the Subtropical Research Laboratory, Weslaco, Tex. 78596.—(By Bennett Carriere, New Orleans, La.) ■

Quick Test for Soil Gases

Through the process of gas diffusion, the balloon assimilates soil gases much as a plant root does. (0782X762-25)

Soil scientist John W. Cary prepares to connect and position his balloon probe in the soil to measure the oxygen and carbon dioxide concentrations in the field. (0782X762-21)

A quick and simple method for measuring oxgen and carbon dioxide in the soil is now available for research use.

Developed by ARS soil scientist John W. Cary and former University of Idaho soil scientist Cephas B. Holder, at Kimberly and Aberdeen, Idaho, respectively, the new method bases its measurements on gas diffusion.

A long, slender balloon is placed horizontally in the soil and flushed with nitrogen from a portable compressed gas canister for 5 minutes at a rate of 40 milliliters per minute. Oxygen and carbon dioxide diffuse into the balloon through its membrane walls in direct proportion to their concentrations in the surrounding soil. Portable oxygen and carbon dioxide meters at the balloon's mouth measure the gases in the nitrogen stream leaving the balloon.

"The balloon acts like a root in the soil," says Cary. "Diffusion moves the oxygen and carbon dioxide into the balloon from the soil."

The most common current technique for measuring oxygen and carbon dioxide involves withdrawing small samples of soil gases from a buried vertical probe for later analysis. With this method there is always uncertainty as to how well the concentrations of gases in the samples represent the concentrations that plant roots actually encounter.

Oxygen can also be measured by implanting electrodes in the soil and monitoring the movement of electrical current between them. This method works fine, according to Cary, provided the soil is wet. However, the electrodes sample only a tiny bit of soil at a time. Many measurements must be made to get an accurate picture of the soil's condition.

The concentration of oxygen and carbon dioxide in the soil can have significant effects on plant growth. Cary says the new method for measuring these gases will be useful "in a variety of laboratory and field studies concerning root aeration, carbonate chemistry and organic matter decomposition."

John W. Cary is located at the Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.—(By Lynn Yarris, Oakland, Calif.) ■

Celery Needs Less Salty Water

Celery, often grown with saline irrigation water, is moderately sensitive to salt. Not only is total yield reduced by the salt, but market quality of stalk length, width, and thickness are adversely affected as well.

Agronomist Leland E. Francois, Riverside, Calif., found that with each additional "unit"—a unit is about 640 parts per million—of salinity, yield is reduced more than 6 percent.

Cultivated celery comes from wild stock which occurs naturally in marshy habitats from Sweden to Algeria, Egypt, and Abyssinia. The wild stock has been reported to grow in brackish water and accordingly might be classified as a halophyte—extremely salt tolerant. Somewhere along the line from the wild state to domestication, it lost much of that tolerance, Francois says.

Francois, who works at ARS' U.S. Salinity Laboratory, found that few reports were available as to the salt tolerance of celery and most of the available ones were contradictory. Those contradictions and the fact that celery is often grown with saline irrigation waters, prompted him to initiate a study to determine salinity effects.

He found, among other things, that high quality celery could be grown with salinities up to about 1300 parts per million. Thereafter both trimmed and untrimmed plants show a significant weight reduction with each unit increase in root zone salinity.

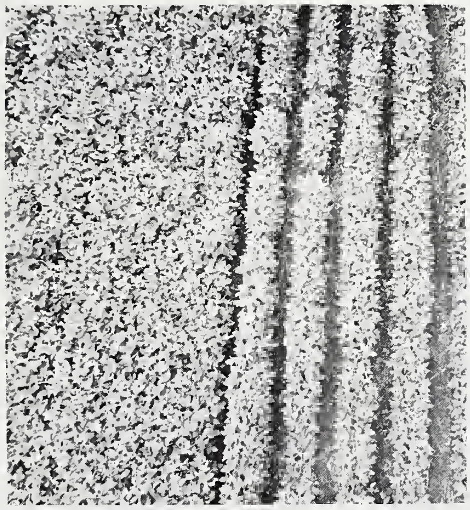
"If a grower expects to produce commercially acceptable celery he must use an irrigation water low in salinity," Francois says.

Leland E. Francois is located at the U.S. Salinity Laboratory, 4500 Glenwood Dr., Riverside, Calf. 92501.—(By Paul Dean, Oakland, Calif.) ■

Solid Seeding Outyields Row Beans

Drilled soybeans averaged 4 more bushels per acre than beans planted in 30-inch rows in 2-year tests at two locations in Iowa.

Tom S. Colvin and Donald C. Erbach, both ARS agricultural engineers at Iowa State University, tested five solid seeding systems as well as a row-planter.



Experimental solid-seeded and 30-inch row soybean plots. (1081X1289-26)

All five systems outproduced the row-planter, Colvin says. The grain drill produced 52 bushels per acre. The four other solid seeding methods—broadcast, press drill, renovator, and a field cultivator with an air seeder attachment—all yielded more than 50 bushels per acre. The row-planter averaged 47.9 bushels.

Two tillage systems, reduced tillage and conventional tillage, were also evaluated. Corn residue from the previous crop varied from as little as 2 percent surface coverage on plowed ground to as much as 74 percent coverage on some reduced tillage plots. However, no significant relationship showed up between yields and residues, Colvin says.

All the solid seeding systems developed a soil protecting canopy earlier than the row-planting system. The drill produced the quickest soil cover, achieving more than 30 percent coverage—about three times more canopy than the row-planting—at 4 weeks after planting.

The Iowa State University experimental plots were located in central and northeastern Iowa. Corsoy beans were planted in late May in all tests. All plots received preplant-incorporated herbicide treatments and a post-emergence application which provided effective weed control, Colvin says. Row plots were cultivated to provide typical field conditions.

"Based on this study, solid seeding soybeans through corn residues after reduced tillage is an acceptable soybean production system. Since all the solid seeding methods tested produced better yields and canopy development, the selection the farmer makes among solid seeding methods is less important than making the decision to use solid seeding rather than row planting," Colvin says.

Tom S. Colvin and Donald C. Erbach are located at Davidson Hall, Rm. 219, Iowa State University, Ames, Iowa 50011.—(By Ray Pierce, Peoria, Ill.) ■

Hilling Sugarbeets Increases Root Rot

"Hilling sugarbeets increases the severity of root rot," says Charles L. Schneider, ARS plant pathologist.

"Root rot, caused by the soil-borne fungus *Rhizoctonia solani,* is one of the most damaging sugarbeet diseases in the country. And, there are indications that the disease is increasing in both incidence and severity," Schneider says.

To evaluate damage caused by hilling soil up around sugarbeet crowns, Schneider and ARS research agronomist George J. Hogaboam ran greenhouse and field studies at Michigan State University. They compared root rot damage to beets that had *R. solani*-infested soil hilled up around the crowns with damage to beets without soil around the crowns.

Cooperating ARS researchers Earl G. Ruppel and Richard J. Hecker, stationed at Colorado State University, Fort Collins, Colo., also ran field tests on the root rot problem.

"Incidence and severity of root rot were significantly greater in the hilled plots of both susceptible and resistant varieties. The percentage of healthy and harvestable roots was significantly decreased in the hilled beets," Schneider says.

In the Colorado tests, for example, harvestable beet yields from resistant lines were reduced by 7.5 percent the first year of tests and 4.4 percent the second year compared with beets not receiving hilling treatment. Susceptible lines suffered increased root rot losses, as high as 22.5 percent, when hilled.

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"We have suspected for a long time that cultivation operations known as ditching-out, or hilling has aggravated root rot. This final cultivation of the season throws soil in and around the crowns as equipment moves by at high speeds, 4 to 8 mph. Where sugarbeets are irrigated, growers ditch-out to provide channels for irrigation water, to control weeds, and to provide guides for harvesting equipment. In nonirrigated areas the hilling practice covers weeds and provides soil support to high-crowned beets," Schneider says.

He suggested several possible solutions to the problem: (1) reduce tractor speed to 2 to 3 mph; (2) in western irrigated areas only, plant in preshaped beds or in wider rows, or both; or (3) use cultivator shoes with shields to reduce the amount of soil reaching the beet crowns.

Charles L. Schneider's address is P.O. Box 1633, E. Lansing, Mich. 48823.—(By Ray Pierce, Peoria, Ill.) ■

Extending the Aquaculture Season

Aquaculture in this country is currently a summertime activity because cold winter water temperatures limit the growth rate or even kill several of the more productive species of fish.

Fish farmers across the southern tier of states, however, might be able to improve on that situation with the use of transparent plastic covers, says an ARS soil scientist.

Bruce A. Kimball, Phoenix, and George B. Brooks, who at the time was an Arizona State University graduate student, used a greenhouse computer model to predict what would happen to the water temperature in a pond covered by plastic sheeting.

They found that a double layer of transparent sheeting suspended above the water surface could increase the water temperature by about 16° F (9° C).

"That temperature rise is enough to permit wintertime production in the southern states and the economics appear favorable for most growers," Kimball says.

"Even more economically attractive would be a nursery culture system where only a small fraction of the ponds are covered with plastic in the wintertime and densely stocked with fry. Then at the beginning of summer, the fry (now fingerlings) are dispersed to other ponds. This nursery system would extend the growing season by 2 to 3 months and should provide a large yield increase for little extra cost," he says.

Bruce A. Kimball is located at the U.S. Water Conservation Laboratory, 4331 E. Broadway Rd., Phoenix, Ariz. 85040.—(By Paul Dean, Oakland, Calif.) ■

Abscission Agents' Effects on Orange Flavor

The flavor of orange juice, as well as the flavor and aroma of orange-peel oil added to food and pharmaceuticals, can be affected by certain chemicals sprayed on trees to facilitate mechanical harvesting, according to ARS chemist Manuel G. Moshonas.

Wide use of mechanical harvesting equipment (blowers and shakers)—which the citrus industry anticipates and scientists are preparing for—will require that abscission agents be sprayed on the trees from 5 to 7 days before harvest.

Moshonas and chemist Philip E. Shaw have found seven flavor-altering compounds, previously identified in other foods but never before seen in citrus products, in peel oil from oranges treated with some types of abscission agents that loosen the fruit by injuring the rind, where the oil sacs are located.

The concentration of eugenol, the most potent of the newly discovered compounds, was 20.8 parts per billion in pasteurized canned juice. Although this concentration is slightly below the point at which a difference in taste can be detected, it is high enough to cause loss of flavor and aroma when various mixtures of the other new compounds are present.

Moshonas and Shaw recommended using either a lower concentration of the chemicals or a type of agent that does not injure the rind. They also recommend harvesting sooner—within 3 or 4 days after application of abscission agent. The fruit would then be less likely to produce the newly fo[illegible] compounds.

The flavor and aroma of peel oil[illegible] valuable to the citrus industry, although the quality of orange juice is of primary importance. Peel oils are used as flavoring in cakes and cough drops, as a scent in furniture polish, and in a great variety of other manufactured products.

Manuel E. Moshonas and Philip E. Shaw are located at the U.S. Citrus and Subtropical Products Laboratory, P.O. Box 1909, Winter Haven, Fla. 33880.—(By Peggy Goodin, New Orleans, La.) ■